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SUMMARY

Compensation funds paid by B.C. Hydro as a result of reservoir flooding provided an opportunity to fund research on mountain caribou in the area north of Revelstoke, B.C. Access to and visibility of animals influenced the frequency of incidental and ground sightings in most habitats. Aerial locations of radio-collared caribou provided data for estimates of habitat use. Annual home ranges were similar in size to those in other areas, averaging 263 ± 73 km^2 . Caribou seldom used the same seasonal ranges in consecutive years and showed little fidelity to specific areas, except in summer. Caribou moved from high to low elevations and back twice each year. Alpine parkland and forest were the key habitats used in late-winter. In spring, most caribou descended into the cedar-hemlock forests where understory vegetation, natural openings and the cleared reservoir provided green vegetation. Caribou emerged from winter in poor condition and quality spring foods were believed important, particularly to pregnant cows. In early June, pregnant cows moved back to higher snow-covered areas to calve in areas virtually free from predators. Other caribou moved more gradually back to higher elevations in June and July. In summer and fall, most forested habitats were used over a range of elevations, with greatest use in high elevation spruce-fir forests. Food and mobility was most restricted in early-winter when deep, soft, snow-covered ground vegetation and made movement difficult. Caribou selected low elevation cedar-hemlock forest at this time and keyed in on active logging areas to obtain arboreal lichens on felled trees. Forested habitats were used year-round while immature forest 20- to 100-years-old were avoided. The caribou population was estimated to be 275 in 1985, a 38% increase since 1983. Spring counts averaged 38% cows, 41% bulls and 20% calves (<1-year-old). The most accurate counts were achieved in March when group sizes were largest (7.2 animals/group) and sexual segregation was minimal.

Nineteen percent natural mortality was observed among radio-collared adults, mainly from snow avalanches. Low hunting mortality was observed as caribou were inaccessible and difficult to locate during the short and early hunting season. Poaching was not a problem, however the caribous' unwary and gregarious behaviour made them vulnerable to hunters and poachers whenever access was easily available, particularly in early-winter.

Previous habitat management guidelines for caribou may be incomplete because the importance of early-winter and spring ranges was not considered. Logging may create short term food sources for caribou but, because immature regenerating forests are not used, caribou habitats and populations will likely be reduced in the long term. Recent construction of logging roads into previously inaccessible areas will increase harvests. Loss of habitat from logging and flooding the reservoir may also reduce the caribou population. The high natural mortality and vulnerability of caribou, as well as the potential for poaching losses, emphasize the need for conservative harvest quotas and access management. Determining seasonal habitat requirements, defining and mapping key habitats and developing long term range management plans should receive top priority.

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INTRODUCTION

Forest dwelling caribou are grouped taxonomically into one subspecies, Rangifer tarandus caribou or woodland caribou (Banfield 1961). Cowan and Guiguet (1975) classified caribou in British Columbia into osborni and montanus subspecies. Although this nomenclature is not widely accepted, the ecology of mountain caribou is sufficiently distinct to warrant separate treatment. Although Bergerud (1978) disagreed with separate nomenclature, he distinguished between caribou dependent on arboreal lichens (mountain ecotype) and those dependent on ground lichens (osborne ecotype). We adopted Bergerud's approach and refer to the caribou in this study as Rangifer tarandus caribou, mountain ecotype.

Woodland caribou populations are declining in British Columbia and are no longer present on many of their former ranges (Bergerud 1978). Because the mountain ecotype is dependent on tree-borne lichens, it is particularly vulnerable when extensive range destruction occurs as old-growth forests are harvested. The young productive forests favoured by forest managers support poor lichen crops and, therefore, do not support mountain caribou. This wildlife-forest management conflict has stimulated renewed interest in both caribou and forest-lichen ecology (Ministry of Forests and Ministry of Environment 1982).

Extensive literature is available on barren-ground caribou (R.t. groenlandicus). In comparison, relatively little information is available for mountain caribou. Most studies are short term and rely mainly on sightings or tracks for much of their information (Freddy 1974; Bloomfield 1979; Russell and Russell 1976). The year-round habitat requirements of mountain caribou and critical seasons are poorly defined. The purpose of this study was to define the most critical time periods and habitats of mountain caribou using radio-collared animals.

STUDY AREA

The study area lies within the Interior Wet Belt and encompasses the drainage of the Columbia River between Revelstoke and Mica, B.C. (Figure 1). Elevations range from 460 m (1500 ft.) on the Columbia River to 3050 m (10 000 ft.) at the highest peaks. Snowfall averages 390 cm at Revelstoke and 2024 cm at Mount Copeland (elevation 1865 m). Despite the rich and diverse vegetation in the area, few large mammals can survive the heavy snowfall in winter (Canada Land Inventory 1973). The area supports populations of moose (Alces alces), goat (Oreamnos americanus), grizzly and black bear (Ursus arctos, U. americanus) but few deer (Odocoileus spp.) and no elk (Cervus elaphus) or mountain sheep (Ovis canadensis) are found.

Many large rolling plateaus occur both east and west of the Columbia River at about 1830 m (6000 ft.) elevations. These plateaus are predominantly within the Engelmann Spruce-Subalpine Fir Parkland forest zone (ESSP) (Krajina 1969). Upper slopes from 1370 m (4500 ft.) to 1830 m (6000 ft.) are within the Engelmann Spruce-Subalpine Fir (ESSF) zone and have continuous forest cover with increasing canopy closure at lower elevations. Below 1370 m (4500 ft.), the forest cover is predominantly western redcedar (Thuja plicata) and western hemlock (Tsuga heterophylla) within the Interior Cedar Hemlock (ICH) zone. These forests have denser canopies and less undergrowth than the spruce-fir types. The area below 570 m (1880 ft.) was completely cleared between 1978 and 1983, for reservoir development; flooding began in October 1983.

Arboreal lichen (Alectoria jubata, Alectoria spp.) abundance and availability varies with forest type and snowpack. In low elevation cedar-hemlock forests, little lichen grows beneath the canopy. Lichens only become available to caribou when trees or branches fall. In spruce-fir forests, lichens grow down to 3 m on standing trees (Stevenson 1979) and are most abundant at 7 m (Detrick 1985; Simpson et al. 1985). Caribou, therefore, require a 2- to 3-m snow platform to reach lichens in spruce-fir forests.

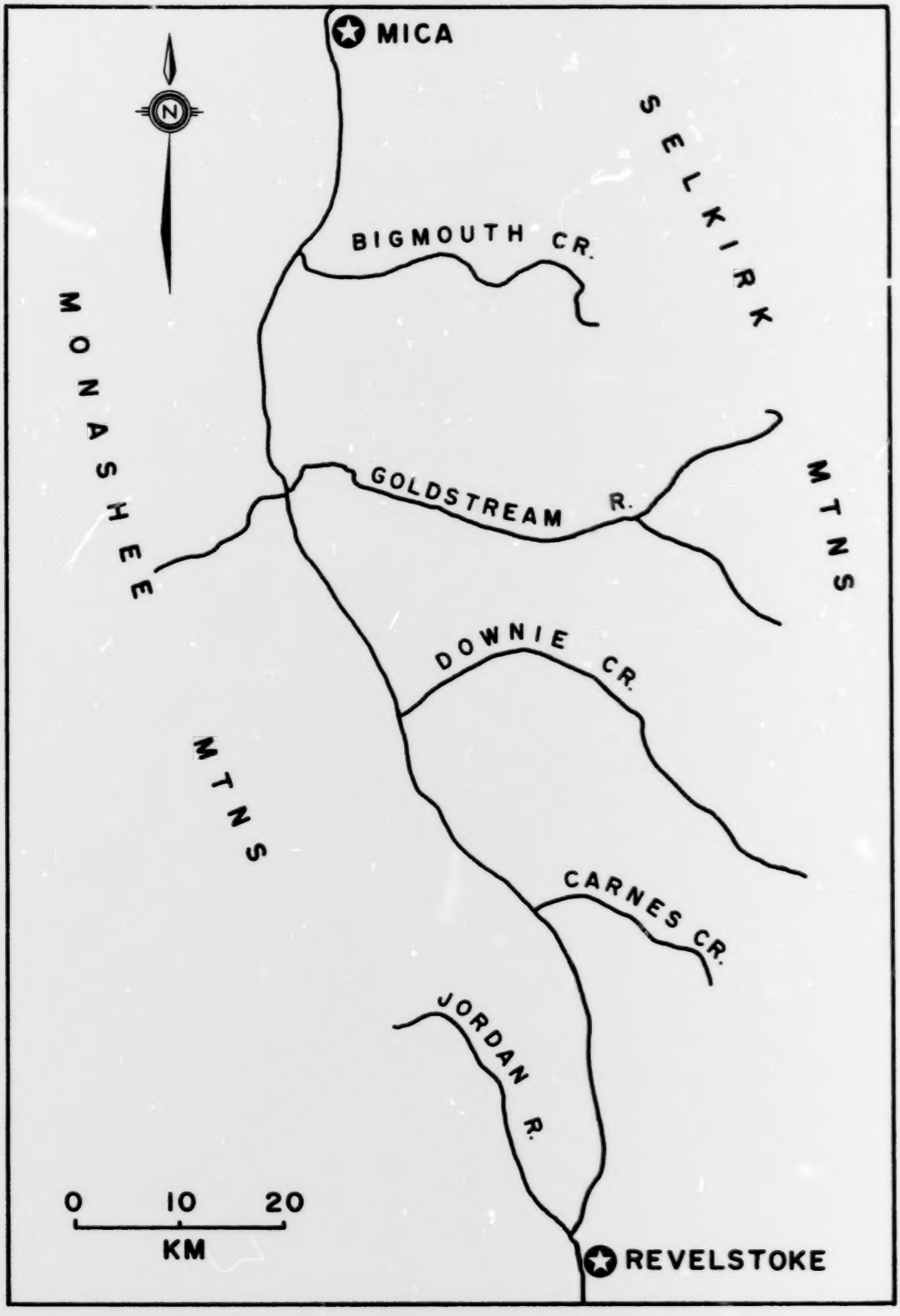

Figure 1. Map showing the major tributaries of the Columbia River in the study area.

METHODS

CAPTURE AND COLLARING

Caribou were captured by darting with Anectine (succinylcholine chloride). Animals were approached on foot in active logging areas or, in alpine parkland areas, were driven by helicopter to gunners concealed on the ground. Once immobilized, each animal was put in a sternal recumbent position, its head covered, and its respiration rate checked. Animals were then radio collared and standard morphological measurements were taken. The general physical condition of each animal was recorded and any unusual marks or injuries were noted.

RADIO TRACKING AND DATA COLLECTION

All radio-collared animals were located approximately every 2 weeks, from March 1981 to September 1985, using helicopter or fixed-wing aircraft. The accuracy of aerial radio locations was verified, whenever possible, by observing animals or tracks. The distinct topography and many watercourses in the area made mapping of animal locations relatively easy. Forest cover and site characteristics, such as estimated ground elevation and aspect, were recorded during each flight using aircraft instruments. Topographical maps and aerial photos were used to verify animal location data prior to coding on computer data sheets. Approximate ground locations were also made for some animals by plotting the intersection of three or more bearings from known locations. Tracks, pellets, and visual sightings were used to confirm the accuracy of ground locations. Home ranges were mapped using the minimum area method (Dalke 1942).

Time and activity data were recorded for sighted groups and, whenever possible, these groups were classified by sex and age. Group size was estimated by counting tracks or beds when animals were not sighted. Similar data were recorded for incidental (non-radio) locations.

Most information was obtained from November to July each year. We subdivided the year into four seasons: early-winter (Nov. 1 to Jan. 15), late-winter (Jan. 16 to Apr. 15), spring (Apr. 16 to May 31) and summer (June 1 to Oct. 31). Although these periods varied in length, they represented distinct shifts in food, habitat, and elevation use by caribou. References to seasons in this report refer to those time periods and should not be confused with traditional calendar seasons.

Radio location data were subdivided by animal, month, season, sex, type of location, and other relevant variables. Chi-square tests were made within each category to determine significant differences ($p<.05$). Yaks correction for continuity was used for 2x2 tests. If no differences were found between groups, the data for each category were combined into broader categories. For example, if no differences were found in habitat selection between individual caribou, then all data were combined into male or female categories, if no differences were found between males and females they were grouped together. Small sample sizes when using a large number of categories may have limited our ability to discern differences in some cases.

HABITAT CLASSIFICATION AND AVAILABILITY

Habitat units were classified based primarily on forest cover and biogeoclimatic groupings were classified based on forest cover mapping. Most of the study area was within Tree Farm Licence (TFL) #23. Maps produced by the TFL owner, Westar Timber, were used as the working base for our calculations. The TFL was subdivided into compartments in which the acreage of each timber type was mapped and tabulated. These tables were used to calculate the acreages of nine main caribou habitat components: Interior Cedar-Hemlock (ICH), Engelmann Spruce-Subalpine Fir (ESSF), alpine parkland (ESSP), areas logged within the past 20 years (SLASH), Interior Alpine Tundra (IAT), immature forest (20-100 years) in both the ICH and ESSF types (IMMAT), avalanche paths (AVAL), and riparian meadows (RIPAR). Areas burned by forest fires (BURN) varied in age but all were tabulated as not sufficiently restocked (with conifers) or as deciduous forest. Non-vegetated rock, ice and snow-covered areas were tabulated but were not included in the use-availability analyses. Using acreage data from those compartments that approximated the home ranges of caribou gave a measure of availability for each habitat component. The frequency of location of radio-collared animals in each component provided use data. Expected use was calculated from the availability of each habitat component and provided an index of component use. Chi-square analysis was used to determine if observed occurrence in habitat components was significantly greater (or smaller) than expected. Simultaneous 95% confidence intervals were calculated for observed use in each habitat component (Neu et al. 1974). Where the expected proportion of usage did not lie within the interval, we concluded the expected and actual use were significantly different. Observation of more use than predicted from habitat availability suggests selection.

FOOD HABITS

Food habits of caribou, particularly in winter and spring, were documented through observation of animals, examination of feeding sites, winter tracking, and fecal analysis. Detailed methods and results of winter tracking are given in a separate report (Simpson et al. 1985). Pellet groups were collected for fecal fragment analysis and to determine the nitrogen content, a correlate of protein in the diet. Analyses were done at the Ministry of Environment, Soils Laboratory, Kelowna, B.C. and the University of Colorado Particulate Analysis Laboratory. Sample treatment and analysis methods are discussed in Hansen and Lucich (1980) and Association of Official Analytical Chemists (1985). Feces crude protein was estimated to be 6.25 X total nitrogen.

POPULATION STRUCTURE AND SIZE

Additional flights were made in late March, when caribou were more observable, from 1982 to 1985 to obtain estimates of the total population and herd composition data. Fixed-wing aircraft were used to search the alpine parkland habitats not regularly covered by radio location flights and to count the caribou. These flights were followed by helicopter flights to classify the animals in each group. Animals were classed as calves (<1-year-old) by body size and bulls or cows by presence or absence of the black vulva patch or penis sheath. Mature bulls could also be identified by their large chest and tapered body shape. Antlers were absent on many animals in late March and provided poor criteria for classification.

RESULTS

CAPTURE AND COLLARING

Fourteen caribou were captured, all by darting with Anectine. Effective doses were 17-22 mg for adult cows and 17-21 mg for adult bulls (Appendix A). Nine cows and three bulls were darted with dosages ranging from 15-20 mg with no effect. Fourteen milligrams administered to a female calf and 21 mg given to a cow stopped their breathing but they were resuscitated by pumping their chests. Cows were less susceptible to Anectine than bulls and were less consistently immobilized. Animals in poorer condition generally had shorter induction times, remained down longer, and recovered full muscle control more slowly. Others have found 15%-25% mortalities common in caribou capture programs using drugs (Fuller and Keith 1981; T. Antifeau, M. Bloomfield , pers. comm.). We suffered no drug-related mortalities primarily by using conservative dosages.

One caribou was captured by darting directly from the helicopter and seven by herding the animals to gunners concealed on the ground. The rest were darted after stalking them along skid trails in winter logging areas. Capture without use of helicopters was less expensive and less traumatic for the caribou since no chase was involved.

Six adult cows were similar in size, averaging 206 $\pm$ 4.2 cm ($\bar{x}\pm$SE) in total length and 122 $\pm$ 2.2 cm in chest girth. Mature bulls were distinctly larger, averaging 232 $\pm$ 4.4 cm (N = 5) in total length and 145 $\pm$ 2.5 cm in chest girth (Appendix A).

All 14 animals captured were ear tagged and 13 were fitted with radio collars. Two collars stopped transmitting within 2 months, three animals slipped out of their collars, and five died from various causes (Appendix B). Between one and six caribou carried functioning collars during the period of the study. In addition, five of the marked animals, without functioning collars, were resighted, most on late-winter range areas.

SAMPLING BIASES

Many incidental (non-radio) locations were recorded for caribou both from the air (487) and from the ground (194)(Table 1). Both air and ground locations were obtained for radio-collared animals. Use of aircraft meant that all collared animals could be located on each flight. We compared caribou habitat use based on air-radio locations with estimates based on ground and incidental locations. Significantly more incidental sightings were made in open habitats from aircraft whereas most ground locations, both incidental and radio, were within 1 km of road access (Table 1). Road access was only available to approximately 25% of the study area and we made no effort to randomize ground or incidental locations. Therefore, only air-radio locations were used in determining seasonal use of different areas. Incidental sightings and ground locations were used to document presence or absence in some habitats and to define ranges of radio-collared animals.

HOME RANGE

Home range, as defined by Mohn and Stumpf (1966), may be a misnomer for Revelstoke area caribou because they apparently have no distinct ranges. Radio-collared caribou seldom occupied the same seasonal ranges in consecutive years (Figure 2). Two marked cows, however, were resighted during the winters of 1982 and 1983 in the same areas where they were captured in 1981. Also, two cows (No.'s 1 and 2, Figure 1) did return to core areas each summer from which they dispersed to various winter and spring ranges.

Annual ranges varied from 81 to 1117 km^2 in size and reflected the tendency of some animals to move long distances between seasonal ranges (Table 2). Early- and late-winter ranges were generally smaller than ranges in other seasons for each animal. We had little information to compare range size for males and females but they appeared similar. We found no evidence that one sex was more wide ranging than the other.

HABITAT USE

Although caribou wandered unpredictably over the period of this study, their seasonal habitat and elevation use was consistent. Radio-collared caribou showed the biannual elevation migration first reported by Edwards and Ritcey (1959)(Figure 3). Animals moved to their lowest elevations in May each year, when they were occasionally observed in the reservoir area below 570 m. They were found at their highest elevations in March when they occupied late-winter parkland (ESSP) ranges above 1800 m. Major elevation shifts occurred in January, when caribou moved up from early-winter to late-winter habitats, and April, when they moved down from late-winter to spring habitats. Cows moved quickly back to high elevation calving areas in early June. Bulls and immature animals moved more gradually back to higher elevations through June and July (Figure 3). Caribou used moderate slopes on all aspects year-round (Tables 3 and 4). North aspects were used most in spring and summer (Table 4).

Table 1. Effects of visibility and access biases on apparent caribou distributions when using non-radio and ground locations

Type of Observation	No. of Observations	Habitat Type			X^2
		Open	Forested	% in Open	
Air Radio	403	154	249	38.2	
Air Incidental	487	385	102	79.1	152.3[a]
		Road Access			
		< 1 km	> 1 km	% <1 km	
Ground Radio	88	44	44	50	
Air Radio	405	41	364	10	77.8[a]
Ground Incidental	194	152	42	78	276.5[a]

[a] P<.001

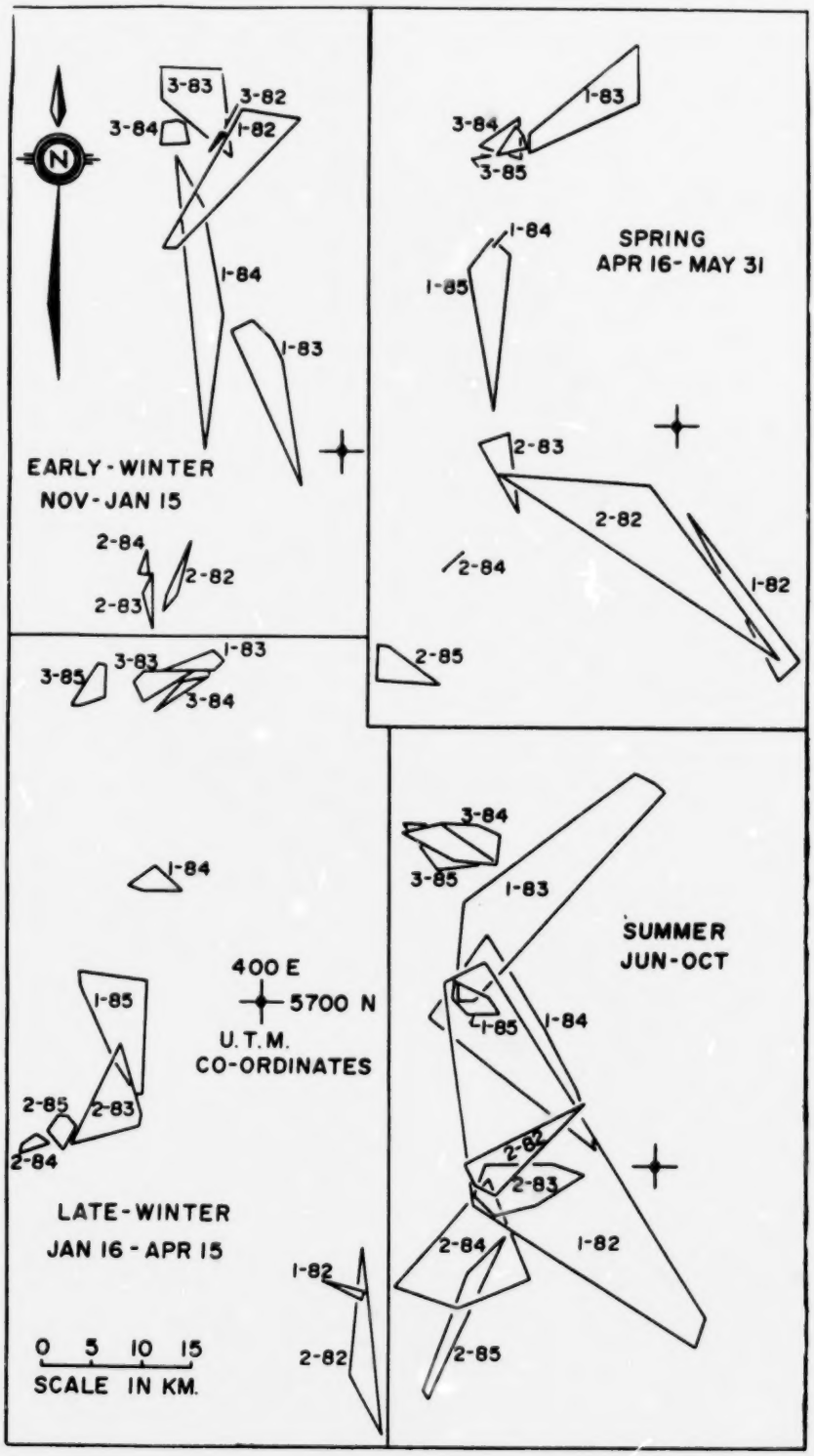

Figure 2. Seasonal ranges, corresponding to Table 2, for cows 1, 2, 3. Universal Transverse Mercator grid co-ordinates and scale are the same for each season.

Table 2. Seasonal and annual home ranges of caribou in km^2

	Year	Home Range (No. of locations)				
		Late-Winter	Spring	Summer	Early-Winter	Annual
Cow 1	82	-- (2)	26 (5)	374 (15)	55 (4)	1117 (26)
	83	8 (7)	45 (7)	151 (11)	34 (8)	515 (33)
	84	8 (6)	-- (2)	124 (10)	60 (5)	261 (23)
	85	50 (14)	37 (6)	10 (12)		137 (32)
Cow 2	82	24 (7)	161 (4)	36 (18)	-- (2)	603 (31)
	83	32 (6)	14 (6)	34 (10)	3 (3)	179 (25)
	84	3 (6)	-- (2)	84 (9)	3 (3)	95 (20)
	85	6 (11)	13 (6)	21 (10)		106 (27)
Cow 3	83	9 (13)	15 (10)	17 (10)	45 (12)	132 (45)
	84	3 (6)	4 (4)	26 (9)	6 (5)	81 (24)
	85	7 (14)	8 (7)	23 (11)		85 (32)
Mean cows		15±4.9	36±16.3	82±32.4	29±9.6	301±97.6
Bull 1	81	-- (3)	-- (1)	41 (10)	37 (6)	159 (20)
Bull 2	83	11 (13)	75 (11)	53 (12)		202 (36)
Bull 3	84	19 (5)	3 (4)	37 (10)	5 (6)	157 (25)
	85	7 (14)	9 (7)	18 (11)		119 (32)
Mean bulls		12±3.5	29±23.1	37±7.3	21±16.1	159±17.0
MEAN ALL		14± 3.8	34±13.0	70±24.2	28± 7.9	263±72.8

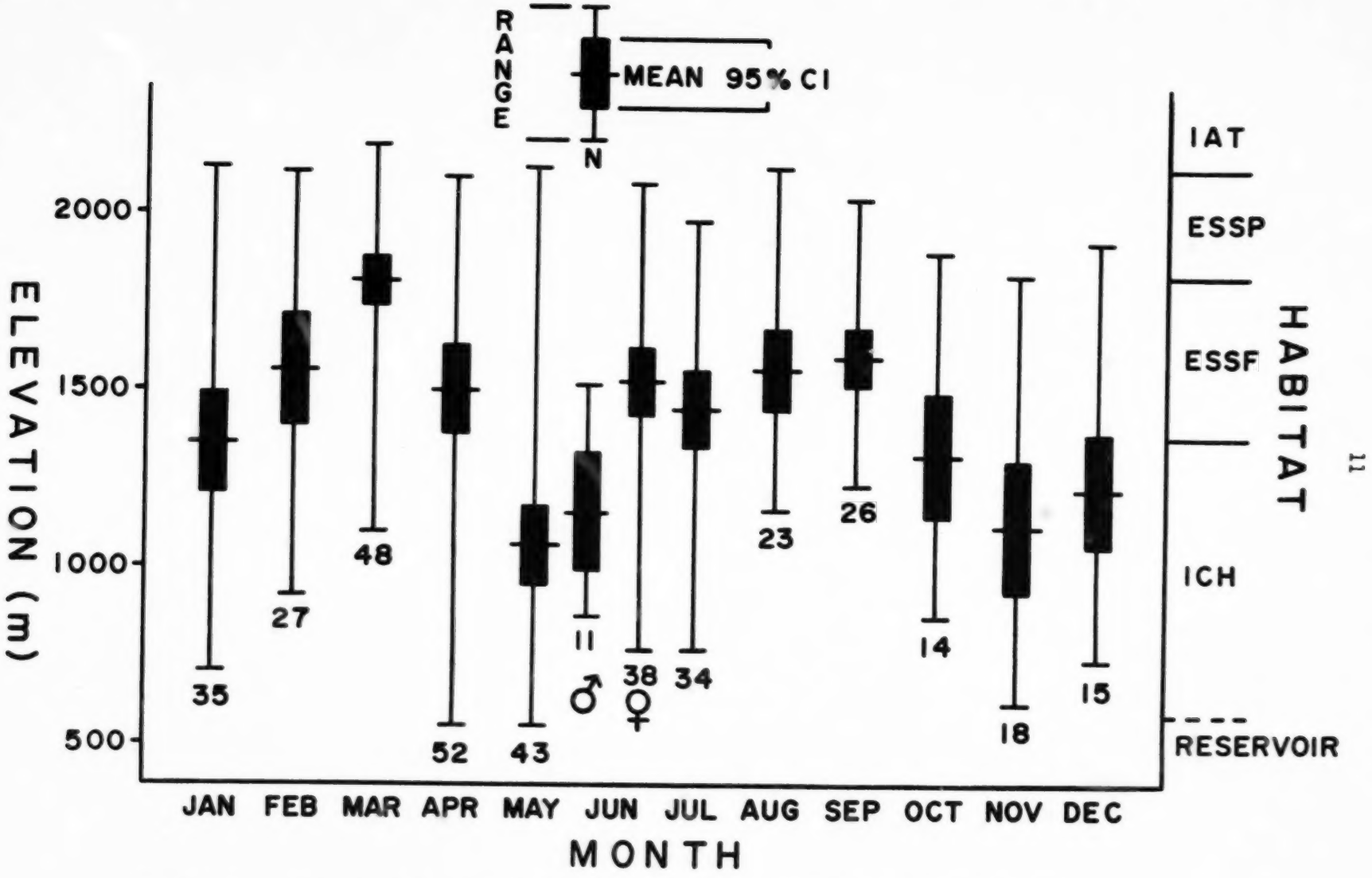

Figure 3. Monthly elevations of radio collared caribou. Cows and bulls differed significantly in June.

Table 3. Seasonal slope use by radio-collared caribou

	Slope (%)			
	Mean	Max	N	SE
Early-winter	26.6	70	55	1.8
Late-winter	24.9	65	132	1.1
Spring	26.8	80	121	1.4
Summer	29.3	70	97	1.5

Table 4. Seasonal use of different aspects by radio-collared caribou

Seasons	No. of Observations	Aspects (% of locations)							
		SE	S	SW	W	NW	N	NE	E
Early-winter	55	4	14	9	24	9	16	6	18
Late-winter	132	6	12	12	19	9	29	4	9
Spring	121	7	10	6	8	8	45	6	10
Summer	97	6	14	4	9	8	41	6	11
ANNUAL	405	6	12	8	14	8	35	5	11

Caribou showed preferences for different habitats seasonally. Alpine parkland (ESSP) received greatest use in late-winter (Table 5). Cedar-hemlock forest (ICH) was most important in spring and early-winter (Table 6) whereas spruce-fir forest (ESSF) was selected in summer (Table 7). As might be expected, no radio-collared animals were located in rock, water and other non-vegetated areas. Immature forest (20- to 100-years-old) was avoided in all seasons. A few caribou were sighted in immature forest but radio-collared animals were never located in this type.

SEASONAL FOOD HABITS

Although caribou used cedar-hemlock forest both in early-winter and spring, food habits were distinctly different. Spring use of forest and clearings was related to feeding on green vegetation, whereas early-winter use was related to feeding on arboreal lichens on windfalls or logger-felled trees. Lichens were the principal food used in winter (Simpson et al. 1985). Mobility and food availability were most restricted in early-winter by deep, soft snow. Lichen on standing trees was the only food available to caribou on late-winter ranges. Caribou used a variety of easily available plant foods in spring and summer (Table 8). Spring foods were not available to pregnant cows when they moved back to snow-covered areas in early June. Ten calving areas examined in June were covered with 1 m of compacted snow and offered little available food, other than litterfall lichen.

Caribou emerged from winter in poor physical condition. Fecal analysis showed that crude protein content of their food increased in May and June as caribou shifted onto spring ranges (Figure 4). Pellets collected from cows in calving areas had significantly lower protein content than pellets collected during the same period at lower elevations (ANOVA $F_{1,83} = 7.98$, $P<.006$). One cow, which lost its calf one week after birth, had a very low fecal protein level (9.2%).

POPULATION STRUCTURE

We suspected that differences in visibility and identification problems affected our sex-age classification data. When all members of each group were not classified, the more difficult members to identify may have been under-represented. We compared our classification data for groups where all were identified with groups where up to one-half were unidentified. There was no significant difference in the percent composition of bulls, cows and calves in either case ($X^2=3.79$, 3 df, $p>.2$). Cows and calves formed a slightly greater proportion in groups where all were not identified. Bulls do not carry antlers during late winter and spring when caribou are most visible, so more bulls or barren cows may go unidentified than cow/calf units, which are easily recognized. The accuracy of caribou classifications likely depends on the methods used and the care taken to identify members of each observed group accurately. Yearling animals, between 1- and 2-years-old, were consistently difficult to identify. Bull caribou attain almost full height in their first year and are only slightly lighter in build than adult females (Appendix A). Most yearlings were therefore classed as cows or bulls.

Table 5. Bonferroni confidence intervals (95%) on use and availability data for late-winter habitat use by mountain caribou

Habitat Type	Expected Proportion of Use	Actual Proportion of Use	Confidence Interval		Relative Use[a]
			-	+	
ICH	.209	.159	.126	.368	0
ESSF	.302	.273	.166	.380	0
ESSP	.150	.515	.395	.635	+
SLASH	.051	.030	-.018	.038	0
RIPAR	.005	.000	-.002	.003	-
IAT	.106	.008	-.013	.029	-
AVAL	.082	.000	-.002	.003	-
BURN	.011	.015	-.014	.044	0
IMMAT	.085	.000	-.002	.003	-
N	1419 km^2	132 locations			

[a] 0 = use in proportion to availability
- = use significantly less than availability
+ = use significantly greater than availability

Table 6. Bonferroni confidence intervals (95%) on use and availability data for early-winter and spring habitat use by mountain caribou

Habitat Type	Expected Proportion of Use	Actual Proportion of Use	Confidence Interval		Relative Use
			-	+	
ICH	.209	.414	.311	.517	+
ESSF	.302	.264	.171	.357	0
ESSP	.150	.126	.056	.196	0
SLASH	.051	.080	.023	.137	0
RIPAR	.005	.035	-.004	.074	0
IAT	.106	.000	-.002	.002	-
AVAL	.082	.063	.012	.114	0
BURN	.011	.017	-.010	.044	0
IMMAT	.085	.000	-.002	.002	-
N	1419 km^2	174 locations			

Table 7. Bonferroni confidence intervals (95%) on use and availability data for summer habitat use by mountain caribou

Habitat Type	Expected Proportion of Use	Actual Proportion of Use	Confidence Interval		Relative Use
			-	+	
ICH	.209	.247	.126	.368	0
ESSF	.302	.515	.374	.656	+
ESSP	.150	.175	.068	.282	0
SLASH	.051	.010	-.018	.038	-
RIPAR	.005	.021	-.019	.061	0
IAT	.106	.031	-.018	.080	-
AVAL	.082	.000	-.003	.003	-
BURN	.011	.000	-.003	.003	-
IMMAT	.085	.000	-.003	.003	-
N	1419 km^2	97 locations			

Table 8. Food plants used by caribou at 35 spring feeding sites

Species	N	Species	N
Sedges (*Carex* spp.)	12	*Lysichiton americanum*	5
Horsetails (*Equisetum* spp.)	11	*Athyrium filix-femina*	4
Streptopus amplexifolius	11	*Epilobium angustifolium*	4
Vaccinium membranaceum	9	*Claytonia lanceolata*	3
Grasses (Poaceae)	9	*Platanthera* spp.	3
Streptopus roseus	8	*Sorbus sitchensis*	3
Gymnocarpium dryopteris	7	*Juncus* spp.	3
Vaccinium ovalifolium	6	*Aralia nudicaulis*	2
Smilacina racemosa	5	*Disporum hookeri*	2
Lichen litter	5	*Erythronium grandiflorum*	2

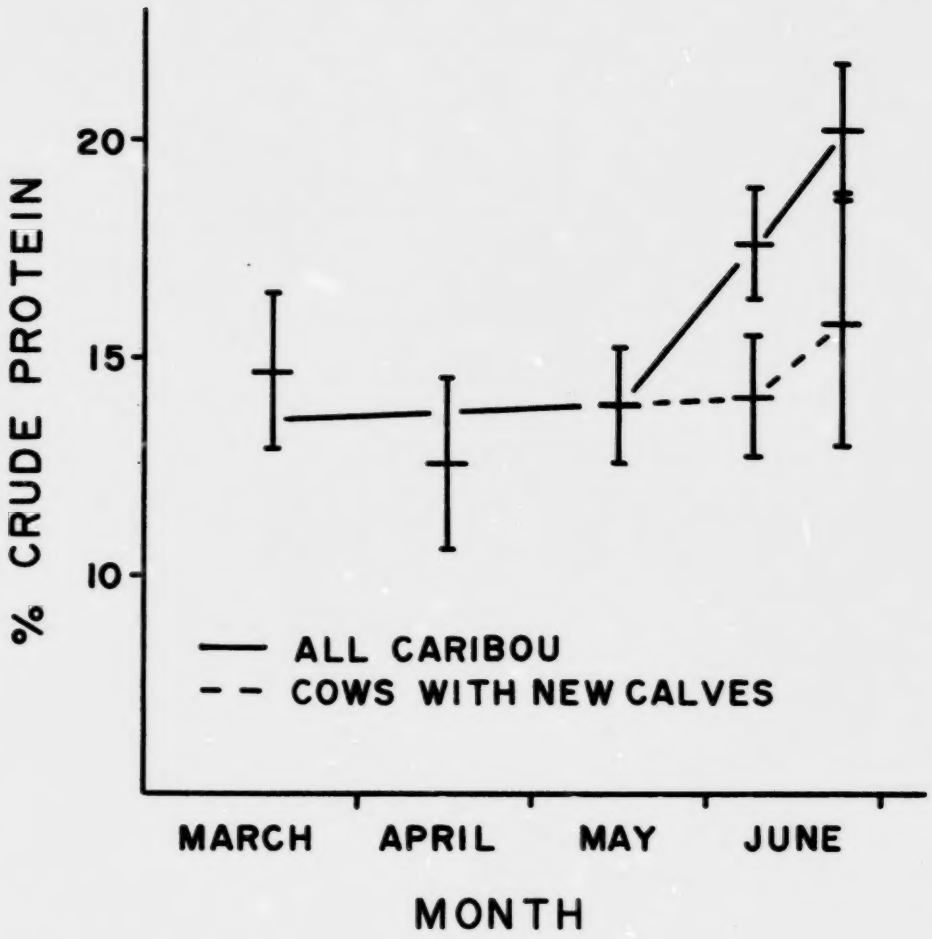

Figure 4. Crude protein in the feed of caribou as estimated by fecal nitrogen analysis ($\bar{x}$±95% C.I.).

We found that group sizes varied seasonally for caribou. Track counts provided a reliable estimate of group size in spring and summer when groups were small (Table 9). Track counts resulted in significant underestimates of group size in early- (31% under) and late- (57% under) winter when compared with counts of animals (Table 9). Individual tracks became difficult to discern when there were many animals in a group. Overall groups sizes were largest in late-winter (7.2 animals/group) and averaged 4.1 animals/group at other times of year.

Sexual segregation in caribou groups also varied seasonally and was probably related to group size. About 40% of the groups encountered from spring to early-winter were single animals or cows accompanied only by their offspring (Table 10). Of the remaining 60%, approximately equal numbers were all male, all female or mixed groups. In late-winter, there were significantly more mixed groups (61%), than in other seasons (x= 23%) (X^2 = 35.5, 1 df, p<.001). As group sizes increased, the proportion of groups containing adults of both sexes also increased. There were more mixed groups during the breeding season (September - October) but caribou were difficult to observe during this period so few groups were classified. Of the six groups sighted during these months, four were of mixed sex.

Herd composition, based on classification counts, differed significantly between seasons (X^2=19.65,6 df, p<.01) and there were some important trends. The male/female ratio was equal at all seasons except in early-winter and in spring (Table 11). Most early-winter classifications were made in active logging areas where lichen was easily available on fallen trees. We believe mature bulls used these areas more than other caribou to recover some of the weight lost during the rut. Cows may have used spring ranges more than other caribou to obtain the high protein food necessary to support new-born calves in June, when food would be scarce because of movement to snow-covered calving ranges. The numbers of calves per cow was highest in summer, shortly after calving, as expected. Twenty-four of the 34 summer classifications were made in June or July. Because some of the females counted were non-breeding yearlings or 2-year-olds the calves per adult cow reported here are conservative, whereas the number of calves per 100 cows varied from 21 to 95 with an overall mean of 53 (Table 11).

Calves, as a percent of the total population, ranged from 27% to 16% with an overall mean of 20% (Table 11). These figures were affected seasonally by over-representation of bulls in early-winter counts. Over-representation by cows in spring counts did not inflate the calf count as expected. The reasons for few of the past year's calves (now yearlings) were observed in spring were not clear. Radio-collared cows moved to calving areas alone in eight of nine occasions and must have chased previous offspring away sometime during spring. Fewer cows on spring calving ranges would, therefore, be accompanied by the previous year's offspring. Abandoned yearlings were observed in spring. Their confused behaviour and lack of wariness suggested that they were vulnerable to predators. We did not observe any such predation, however.

Table 9. Seasonal changes in caribou group sizes and reliability of number estimates based on tracks

Season	Count Type	Mean	Max	SE[a]	N	
Spring	Tracks & Animals	4.1	32	.25	200	
Summer	Tracks & Animals	3.7	13	.49	57	
Early-winter	Animals	4.2	27	.31	136	t=2.19, df=203, P<.03
	Tracks	3.2	10	.22	71	
	TOTAL[b]	4.1	32	.17	393	t=9.98, df=666, P<.001
Late-winter	Animals	7.2	28	.28	275	t=6.68, df=498, P<.001
	Tracks	4.8	18	.20	225	

[a] Standard error
[b] Excludes early-winter track counts.

Table 10. Sexual segregation of groups of caribou observed during different seasons

Season	Group Composition (% of Groups)					No. of Groups
	Females Only	Single[a] Female	Males Only	Single Male	Mixed Sexes	
Spring	24	34	16	10	16	47
Summer	0	30	18	15	37	56
Early-winter	15	17	28	15	25	72
Totals	17	26	21	13	23	175
Late-winter	12	11	13	3	61	101

[a] Cows accompanied only by a yearling or calf were classed as single females.

Table 11. Caribou sex and age classifications during different seasons

Season	Cohort Year[a]	% Composition				Calves/ 100 Cows	N	No. Groups Classif.
		Male	Female	Yrlg	Calf			
Summer	81	63	21	0	16	76	19	10
June-Oct	82	23	44	10	23	52	39	13
	83	42	33	0	25	76	36	13
	84	40	40	0	20	50	5	3
	85	22	40	0	38	95	40	17
Mean		34	37	3	27	73	Total 139	56
Early-winter	81	21	51	0	28	55	43	13
Nov.-Jan.	82	51	33	0	16	48	98	31
	83	61	19	3	17	89	36	9
	84	56	29	6	9	31	69	19
Mean		49	33	2	16	48	Total 246	72
Late-winter	80	43	39	0	18	46	28	7
Jan.-Apr.	81	31	42	0	27	64	139	27
	82	38	41	0	21	51	146	24
	83	44	36	0	21	58	101	20
	84	52	31	0	17	55	164	23
Mean		41	37	0	21	57	Total 578	101
Spring	80	0	56	11	33	59	9	2
Apr.-May	81	26	55	0	19	35	47	15
	82	46	36	1	17	47	72	23
	83	0	60	0	40	67	5	1
	84	33	56	0	12	21	43	6
Mean		34	48	1	18	38	Total 176	47
OVERALL MEAN		41	38	1	20	53	GRAND TOTAL 1139	276

[a] eg. Cohort year 81 = June 1981 to May 1982.

Late March to early April was the best time of the year to census and classify caribou. Group sizes were large, animals were in open terrain and sexual segregation was minimal. We determined that the population consisted of equal numbers of bulls and cows, which incorporated an unknown percentage of yearlings and subadults and 21% calves. The annual total for all seasons yielded similar results to those found in late-winter alone (Table 11) because spring counts, which over estimate cows, were compensated by early-winter counts, which over estimate bulls.

POPULATION SIZE

The caribou population in the study area had been estimated three times prior to our study (Table 12). Those estimates were based mainly on interviews with local residents and limited census data. Estimates ranged from 95 to 170 animals with a mean of about 130 animals. Our initial results suggested a similar population size but later surveys covering most of the study area showed that the population was considerably larger. The most animals seen on a single flight was 140 on March 26, 1984. On four flights from March 8 to 18, 1985, we sighted 24 distinct groups between Revelstoke and Mica totalling 261 animals (Table 12). One group of five animals, including a formerly marked animal, was not included in this total because they were outside the previously defined census area. Resightings of marked animals and repeated surveys of the same areas suggested that we were counting a high percentage of the total population. We estimated the population in the area to be 275 to 300 animals in March 1985.

MORTALITY

A surprisingly large number of caribou were found that had apparently died of natural causes (Appendix B). Snow avalanches caused the deaths of at least six animals in two groups. Three other animals died accidentally or from predation by grizzly bears. Adult mortality among 14 radio-collared caribou averaged 19% (5/21 animal years). Although this was a very small sample, it certainly suggests an unusually high natural mortality rate. The chance location of three additional carcasses, apparently dead from natural causes, supported this conclusion.

Direct human-induced mortality, both legal and illegal, was minimal. Four caribou were killed illegally and three legally from 1981 to 1985. Caribou were not generally accessible and were rarely seen during the one month hunting season in September and early October. Caribou became extremely vulnerable to hunters if road access was provided to areas they occupied during the hunting season. About 10 caribou were shot in the Jordan River drainage, northwest of Revelstoke, when road access was provided for high elevation logging. That area was closed to hunting shortly thereafter. Caribou were easily accessible to hunters in early-winter when they frequented active logging areas. We had two unconfirmed reports of animals being shot in those areas but found no evidence of illegal kills. Loggers had a protective attitude to the animals and frequently blocked the access roads on weekends when they were not working. Caribou are valued mainly as a trophy animal and many people consider the meat unpalatable or tasteless. Most bulls lose their antlers before they move into logging areas so their value as trophy animals

Table 12. Caribou counts and population estimates in the Columbia Mountains 1975-1984

Counts		Population Estimates			Source
Animals	Tracks	Mean	Min	Max	
		140	110	170	Russell & Demarchi 1975
		150			Environmental Resource Consultants 1976
			95	135	Keller & Berry 1979
		118	67	184	Simpson & Hebert 1982
111	55	200[a]	192[b]		This study, March 1983
140	7	255[c]	195[d]		This study, March 1984
177	53	275	261[e]	300	This study, March 1985

a 5 of 9 marked animals sighted among 111 seen. Therefore total population was 9/5 x 111 = 200.

b 111 observed plus (55 tracks x 1.5 correction) = 192 [correction factor computed from Table 9: 7.2/4.8 = 1.5]

c 6 of 9 marked animals sighted among 140 seen. Therefore total population was 9/6 x 140 = 210 + 45 (estimate for unsurveyed north portion) = 255.

d North 1/3 of study area not censused in 1984. Estimated minimum of 45 additional animals in this area from 1983 census. Counts - 140 + 45 + (7 x 1.5) = 195.

e Entire area censused Mar 8-18. South of Bigmouth: 157 animals + 8 tracks; North: 20 animals + 45 tracks. 5 animals seen outside 1982-84 survey area not included.

drops. All of the above factors were probably important in reducing poaching losses in early-winter.

Poaching and accidental shooting in other parts of the Kootenay region, where caribou seasons were closed, suggested that illegal kills could become a problem in the Columbia Mountains if caribou were accessible earlier in the year or if hunting pressure for other species increased. Six caribou were shot illegally in the southern Kootenays in the fall of 1983 (R. Hoar, T. Grabowski, pers. comm.). All were taken by people hunting for deer or elk.

VULNERABILITY

Caribou behaviour makes them particularly easy to shoot for two reasons: 1. they travel in groups and 2. they are frequently unwary of people or vehicles. We approached caribou 22 times and were ignored until we were within 20 to 30 m. On one occasion, we were almost able to touch a young bull. Several people have reported whole groups of up to six caribou being shot at one time when hunting seasons were more liberal (E. Wallace, H. Grusen, C. Crowley, pers. comm.).

Three factors contribute to the recent low harvest in the Columbia Mountains:

1. the low density population, currently estimated at one animal/18 km^2.

2. the unpredictable movements, so that caribou cannot be located reliably in any specific areas during hunting season.

3. the lack of road access to the majority of the area.

The movements and grouping of caribou also influence public perception of the general abundance of the animals. Loggers and other observers have estimated two to four times the number of animals actually present in active logging areas. A few caribou can extensively track a large area overnight, leading to inflated estimates of the number of animals making the tracks. Groups of caribou are not discrete, with animals frequently leaving or joining each group. Repeat sightings of groups that vary in size and individual composition, coupled with the assumption that groups are discrete, leads many people to believe that they are seeing many different groups rather than a few animals that are mixed differently each time. Adding these "distinct" counts again leads to overestimates. Caribou occasionally congregate in small areas and form large single groups. The largest we observed was 32 animals. A reliable count of 69 animals was made in a logging area during a severe winter (P. Des Mazes, pers. comm.). Observations of large numbers at one location led to the assumption that other large groups existed and that the total population was also large.

DISCUSSION

Accurate determination of caribou seasonal habitat use depended on sampling criteria. Aerial location of radio-collared animals was the primary method of data collection in our study area because of the limited access and the distinct differences in the visibility of caribou in seasonally important habitats. Incidental observations could be used if obtained systematically to avoid the obvious biases associated with differences in observer access and visibility.

Radio-collared caribou seldom used the same geographical areas in consecutive years. For this reason, groups of caribou regularly observed on some winter ranges were likely composed of different individuals each year. Caribou are believed to practice this "range rotation" to reduce the grazing pressure on the slow growing arboreal lichens used as winter food (Bloomfield 1980a; Freddy 1974; Hamer 1974). Discrete seasonal ranges were most noticeable on winter ranges but were also evident during spring and summer. Unpredictable ranges may also be a useful predator avoidance strategy on spring and summer ranges. The lack of success of hunters suggests that this strategy is most effective.

The lack of fidelity to specific areas suggested that caribou may continue to explore new areas for their entire life. If we assume that large varied ranges are a requirement of caribou survival, then any attempt to calculate a minimum area requirement for caribou based on food supply may be meaningless. Certainly a better understanding of the reasons for their extensive wandering is required before conclusions can be drawn about the effects of man-induced environmental changes.

Seasonal habitat use was more predictable than range use. Our results were similar to those reported for other areas with some exceptions. The seasonal use of low elevation cedar-hemlock forest was much greater than previously reported (Freddy 1974; Beets and Russell 1976b; Bloomfield 1980a). Active logging areas, which were occasionally used by caribou in some areas (T. Antifeau, J. Carlton, pers. comm.), were commonly used by caribou in the Columbia Mountains during early-winter. Lichen on felled or windthrown trees was an important food source in early-winter and caribou were efficient at locating and using areas where fallen trees were available (Simpson et al. 1985). Caribou did not use immature forest, either in the cedar-hemlock or spruce-fir types at any time of year. This avoidance was believed related both to the lack of food and to avoidance of predators such as grizzly bears, which were a greater threat in these forest types than other more open habitat types (Simpson 1986).

Caribou food habits were also similar to those previously reported except for their extensive use of litterfall lichen and lichen on fallen trees in early-winter (Simpson et al. 1985). Others have reported that litterfall or windfalls may not be important because they are quickly covered with new snow (Stevenson 1979; Schroeder 1974). Lichen hanging on understory vegetation is easily visible and caribou can locate terrestrial lichens under deep snow (Russell and Martell 1984). Although snowfall and snow depths are greater near Revelstoke than in most other areas, both litterfall and windfalls were important early-winter food sources for caribou.

Lichens used by caribou in winter are considered to be a poor quality food because of their low protein content (Stevenson 1979; Beets and Russell 1976a). Fecal nitrogen data suggest that lactating cows, which have the greatest demand for protein rich food, are nutritionally deprived on calving grounds. Spring foods, although relatively abundant, were available to pregnant cows only for a short period, between the time they moved off winter ranges and back to calving areas. Access to the best feeding sites was restricted by the need to avoid predators in spring (Simpson 1986). The poor condition of caribou after winter, the short duration of high quality spring feeding for cows, restricted access to the best sites and the lack of food in calving areas may contribute to poor calf survival (Dauphine 1976). Fifty to 75% of calves died shortly after birth in the southern Selkirks, an area with limited low elevation range, and inadequate nutrition of cows was the suspected cause (Scott and Servheen 1985). Preservation of contiguous areas of low elevation cedar-hemlock forest may be very important to provide quality feeding areas secure from predators for cows in spring and early-winter snow shelter, ground forage and lichens.

Caribou populations generally have greater numbers of cows than bulls. This has been related to higher natural mortality of adult bulls and hunting pressure selecting for bulls (Parker 1972). Herd composition data comparable to ours, for southern caribou herds, were scarce. Methods of presentation and interpretation also varied considerably. We have extracted figures from several reports, which we believe are comparable to ours (Table 13). Some presented estimates of their population composition (Parker 1972; Fuller and Keith 1981; Scott and Servheen 1985) whereas for others (Freddy 1974; Hatler 1983), we made estimates from data presented in the reports. In general, our population had relatively more calves and bulls and fewer cows than other populations. The timing of composition counts varied in each study and, except for barren-ground caribou, seasonal differences in sexual segregation were not considered. Miller (1974) stated that "Aerial surveys of small land units may give misleading ratios of mature males to mature females..." because of the sexually segregated and non-random distribution of caribou groups. He further stated that this problem could be overcome by repeated surveys of large areas at appropriate seasons of the year. We have attempted to reduce these biases by using repeated counts in all seasons for several years (Table 11). We believe that the proportion of males in mountain caribou populations is significantly larger than observed for barren-ground caribou. This may relate to a need for more bulls to service all cows adequately in the more dispersed and dissected mountain caribou populations.

Table 13. Herd composition data for caribou in this study and others

Caribou Herd & Location	Season		Male	Female	Calf	Total Identified	Source
Kaminuriak N. Manitoba	June	%	33	57	9	100	Parker 1972
N.E. Alberta	Sep.-Feb.	%	40	48	12	100	Fuller and Keith 1981
Spatsizi B.C.	Oct.	N	67	112	29	208	Hatler 1983
		%	32	54	14	100	
Selkirk B.C.	Apr.-Nov.	N	13	16	11	40	Freddy 1974
		%	32	40	28	100	
Selkirk B.C.	Mar.	N	27	34	11	72	Scott 1985
		%	38	47	15	100	
This Study	Mar.	N	465	432	231	1128	This Study
		%	41	38	20	99	

Bergerud (1978) estimated that unhunted caribou populations with >12% calves in spring were increasing. Our spring counts averaged 18% calves and, although we believed this to be an underestimate, it still suggested an increasing population. This was consistent with census data that also indicated an increasing population. This increase continued despite reservoir clearing, logging, low and mid-elevation clear cut and forest fires, which had removed approximately 15% of the available forest by 1984. The first effect of reservoir flooding on caribou, in October 1983, was on calves born in 1984. Cows no longer had access to meadows and cleared areas in the reservoir in spring and predators and prey were confined to smaller areas along the new shoreline. The percent calves counted in March 1985 was the lowest recorded during the study (Table 11). The drop in numbers of calves was not statistically significant, but the loss of spring range to cows was thought to be a possible cause (Simpson 1986).

Mortality from hunting was not considered an important factor in the Columbia Mountains mainly because caribou were inaccessible and difficult to locate during the short early fall hunting season. Changes in access could lead to rapid increases in the harvest in the near future. Caribou are extremely vulnerable to hunters in areas where they are easily accessible and overhunting was believed responsible for the observed declines of many other caribou populations (Bloomfield 1980b; Russell et al. 1982; Bergerud 1978). Based on calf survival, natural mortality among juveniles was lower than other populations but mortality of adults was higher than previously reported (12%, Bergerud 1978). The high mortality was not caused by predators, as expected (Bergerud 1978), but by a variety of accidental occurrences, especially avalanches in late-winter. Actual adult mortality must have been lower than 19%, otherwise, with an annual increment of 18%, the population would not have increased. The surplus available for hunters was limited, however.

Poaching losses continued to be the major source of adult mortality in the southern Selkirks (Scott and Servheen 1985) and probably in other parts of the Kootenays, where roads provide easy access to caribou habitats. Although increasing access to caribou ranges in the Columbia Mountains will probably increase poaching losses, it will be difficult to document or control. Most documented illegal kills in other areas were by hunters looking for other species, mainly deer (Scott and Servheen 1985). There is no deer season in the Columbia Mountains and moose hunters are unlikely to mistake a caribou for a moose. Accidental kills of caribou are less likely in this area where there are fewer hunters searching for fewer species. The incidence of poaching could become a problem in early-winter when caribou are easily accessible and visible.

The public attitude toward caribou will become increasingly important as more caribou habitats are accessed. Overestimates of abundance can be harmful. Resources that are abundant do not receive the careful management and consideration afforded scarce resources. Threatened species receive much more attention and concern than common ones. Liberal hunting regulations in the 1950's and 1960's (Russell et al. 1982) were undoubtedly predicated on overestimates of caribou abundance. Public perception of the abundance and status of the caribou may be very important in determining the consideration given the animals in future resource use decisions.

CONCLUSIONS

Several of our results are most significant because they provide new information or alter previously accepted information on mountain caribou ecology. These are:

1. studies that rely only on aerial sightings or ground tracking rather than including aerial radio telemetry may not give a reliable estimation of seasonal habitat selection by mountain caribou.

2. early-winter and spring ranges are probably as important to caribou as late-winter ranges. Initial calf survival may depend on the quality, quantity and availability of spring ranges to pregnant cows, due to high nutritional requirements during that period.

3. immature forests are of limited value as caribou habitat and may form impassable barriers to caribou.

4. caribou apparently tolerate limited losses of forested habitats (15% in this study). A better understanding of the reasons for the extensive wandering of caribou is required before reliable habitat management guidelines can be produced.

5. caribou suffer high adult mortality (19%) primarily from natural hazards, such as snow avalanches.

6. predators, other than bears, were uncommon in the study area and caribou successfully avoided them by selecting the habitats least used by bears, sometimes at the expense of nutrition.

7. caribou in the Columbia Mountains had a higher percentage of bulls and calves and relatively fewer cows than most other populations. The 2:1 cow/bull ratio observed for barren-ground caribou does not apply to mountain caribou.

8. caribou are extremely vulnerable to hunters in accessible areas and poaching is a potentially important source of mortality.

RECOMMENDATIONS

Based on the above conclusions we recommend that:

1. previous studies based on sighting data be assessed cautiously;

2. the relationship between nutrition of cows, calf survival, and range use should be examined. Factors such as human disturbances, predators, and physical barriers (logging slash),which may inhibit use of quality spring ranges, should be considered;

3. forest harvest managers consider that logged areas will not be used by caribou for <u>at least</u> 100 years and plan harvest schedules accordingly;

4. the response of caribou populations to habitat alterations in different areas be examined to provide some basis to determine minimum area-habitat requirements of caribou. Habitat mapping and realistic long term range management plans require immediate attention;

5. wildlife managers co-ordinate management plans for caribou herds crossing regional boundaries. Reliability of population trend indicators, such as % calves, should be tested by continuing annual censuses and classifications in areas where we have previous data; and,

6. wildlife harvest managers consider the high natural mortality rate of caribou, their vulnerability in accessible areas, and the potential for poaching losses, in setting harvest quotas and developing access management plans.

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Appendix A. Caribou measurements and capture data - drug dosages and effects

Date	Sex/ Age	Total Length (cm)	Chest Girth (cm)	Anec-tine (mg)	Time: Hit Down Up	Loc. of Hit	Condition	Comments
1981								
14 Mar	F cow			15	0847	?		No effect
14 Mar	F calf	177	106	15	1031 1036 1130	neck	fat 5	Assisted breathing. Dead 13 Apr. - wolverine kill.
15 Mar	F cow			16	0910	rump		No effect
15 Mar	F yrlg	205	115	17	1155 1202 1224	rump	fat 5	Kirbyville Cr. yellow tag left ear.
17 Mar	M subad	196	115	17	0923 0927 1027	rump	thin 2	Nichol Cr. fell twice between 1027 & 1041 before fully recovered. Dead 14 Apr.-aval.
20 Mar	F cow	190	128	17	0933 0946 1010	rump	fat 5	Frisby Rdg. Dart penetr. rump. Tag purple #1 left ear
20 Mar	F cow	220	130	17	1148 1153 1228	thigh	fat 5	Martha Cr. Fell twice after standing. Tag blue #1 left ear.

Appendix A, continued

Date	Sex/ Age	Total Length (cm)	Chest Girth (cm)	Anec-tine (mg)	Time: Hit Down Up	Loc. of Hit	Condition	Comments
24 Mar	M bull	219	140	17	1427 1435 1524	rump	thin 1	Frisby Rdg. Dart penetr. muscle. Fell 3X after recovery. Last seen 1545 lying down. Orange tag rt. ear
6 Jun	M bull			17	1030	rear knee		Poor injection site, no effect
15 Dec	M bull	237	146	17	0925 0934	rump	thin 2	Frisby Rdg. Orange #5 tag, rt. ear
15 Dec	F cow			17	1220	shoulder		Dart bounced out. Needle bent,no eff
18 Dec	F cow			17	1602	rump		-15°C, drug freezing? No effect.
1982								
6 Jan	F			18	1100	ankle		No effect
6 Jan	F cow			18		rump		Dart bounced out, frozen drug,no eff
14 Jan	M subad	201	118	18	1616 1626 1706	rump	thin 2	Frisby Rdg., yellow #3 tag, rt.ear no radio
19 Jan	cow			18		rump		Dart bounce,no eff

Appendix A, continued

Date	Sex/ Age	Total Length (cm)	Chest Girth (cm)	Anec-tine (mg)	Time: Hit Down Up	Loc. of Hit	Condition	Comments
19 Jan	cow			19		rump		Good hit, no eff
25 Jan	F cow	201	118	21	1505 1515 1620	rump	fat 5	Frisby Rdg, shallow breathing for 10-15 min. Orang #4 rt. ear tag.
6 Mar	F cow			20	1007	rump		-10°C dart frozen? No effect.
8 Mar	F cow	204	118	22	1042 1049 1134	rump	thin 2	Kelly Cr., shallow breathing 10-15min Fully recovered 1137. Dead 10 Apr. - avalanche
16 Mar	F cow	212	119	22	0952 0956 1040	rump	thin 2	Frisby Rdg, breath. stopped. Rescus. 20 min. Blue tag rt ear
8 Dec	M bull	224	139	19	1150 1157	rump	thin 1	Nichol Cr. dead 13 Oct83, horns locked
12 Dec	F cow	207	119	21	1321 1329 1353	rump	fat	Hill Cr., breathing shallow 10-15 min. Blue tag left ear
1983								
29 Dec	bull			19	1200	rump	thin	No effect

Appendix A, continued

Date	Sex/ Age	Total Length (cm)	Chest Girth (cm)	Anec-tine (mg)	Time: Hit Down Up	Loc. of Hit	Condition	Comments
1984								
31 Jan	M bull	240	145	21	1352 1410 1452	rump	thin 1	Camp Cr, long induction, orange left ear, yellow rt. ear Dead 19Nov85, collision
31 Jan	bull			20	1310	rump	thin	No effect
1985								
8 Oct	bull	240	153				fat	Shot, Kirkup Cr.

Appendix B. Record of caribou mortalities in the study area 1981-1985

Animal(s)	Date	Cause
13 yr. old cow	81 Jan	Starvation resulting from neck injury. Large cyst at base of jaw, gut empty, bone marrow - 12% fat.
Collared female calf	81 Apr	Killed by wolverine, in valley bottom - poor snow conditions.
3 bulls 2-4 yrs. (1 collared)	82 Apr	Killed in avalanche. Parkland habitat.
Collared cow/calf and 1+ others	82 Apr	Killed in avalanche. Kelly Cr. - crossing valley bottom.
1 caribou	83 Feb	Unknown. Found by heliskiers, Nagle Creek. Bill Laurilla - pers. comm.
1 bull	83 May	Unknown. Hunters shot grizzly on carcass. Gold River. Brian Dean - pers. comm.
1 bull	83 Sep	Illegally killed. Seymour Creek area.
1 bull	83 Oct	Found dead near Hwy. 23, believed shot.
2 bulls (1 collared)	83 Oct	Rut, horns locked.
1 bull, 1 cow (both collared)	85 Mar	Transplanted animals. Killed in avalanche on valley side slope.
1 cow	85 Jun	Unknown. Bear on carcass. Transplanted animal.
1 bull	85 Oct	Illegally killed. Kirkup Cr.
1 bull (collared)	85 Nov	Vehicle collision.
1 cow (collared)	85 Nov	Transplanted animal found Mar 86, believed shot.
Total natural/accidental mortality		- 18 (8 bulls, 4 cows, 2 calves, 2 unidentified)
(1981-85) illegal kill		- 3 bulls, 1 cow
legal kill		- 3 bulls

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